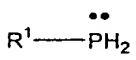
CLAIMS

What is claimed is:

1. A method of synthesizing a diazaphosphacycle, comprising: reacting a phosphine with a diimine and optionally one or more equivalents of an acid halide, a sulfonyl halide, a phosphoryl halide, or an acid anhydride in the substantial absence of O_2 to form the diazaphosphacycle, wherein the phosphine has the formula I

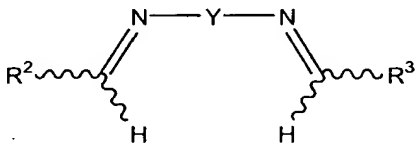


I

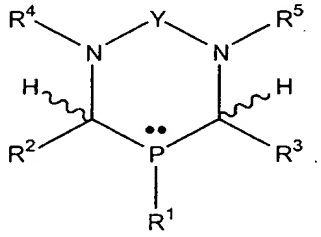
wherein,

R^1 is selected from the group consisting of substituted and unsubstituted aryl groups, substituted and unsubstituted alkyl groups, substituted and unsubstituted alkenyl groups, substituted and unsubstituted cycloalkyl groups, and substituted and unsubstituted ferrocenyl groups.

2. The method of claim 1, wherein the diimine has the formula II, and the diazaphosphacycle has the formula III,



II



III

wherein,

R^2 and R^3 are independently selected from the group consisting of substituted and unsubstituted aryl groups, substituted and unsubstituted alkyl groups, substituted and unsubstituted cycloalkyl groups, substituted and unsubstituted heterocyclyl groups, and substituted and unsubstituted ferrocenyl groups;

R^4 is selected from the group consisting of -H, substituted and unsubstituted alkyl groups, substituted and unsubstituted cycloalkyl groups, substituted and unsubstituted aryl groups, trialkylsilyl groups, triarylsilyl groups, alkyldiarylsilyl groups, dialkylarylsilyl groups, $-C(=O)-R^6$ groups, $-S(=O)_2-R^6$ groups, $-P(=O)R^6R^7$ groups, and $-C(=NR^6)-R^7$ groups;

R^5 is selected from the group consisting of -H, substituted and unsubstituted alkyl groups, substituted and unsubstituted cycloalkyl groups, substituted and unsubstituted aryl groups, trialkylsilyl groups, triarylsilyl groups, alkyldiarylsilyl groups, dialkylarylsilyl groups, $-C(=O)-R^7$ groups, $-S(=O)_2-R^6$ groups, $-P(=O)R^6R^7$ groups, and $-C(=NR^6)-R^7$ groups;

R^6 is selected from the group consisting of substituted and unsubstituted alkyl groups, substituted and unsubstituted alkenyl groups, substituted and unsubstituted cycloalkyl groups, substituted and unsubstituted aryl groups, -OH groups, substituted and unsubstituted alkoxy groups, substituted and unsubstituted aryloxy groups, -NH(alkyl) groups, -NH(aryl) groups, $-N(aryl)_2$ groups, $-N(alkyl)_2$ groups, -N(alkyl)(aryl) groups, -S-alkyl groups, and S-aryl groups;

R^7 is selected from the group consisting of substituted and unsubstituted alkyl groups, substituted and unsubstituted alkenyl groups, substituted and unsubstituted cycloalkyl groups, substituted and unsubstituted aryl groups, -OH groups, substituted and unsubstituted alkoxy groups, substituted and unsubstituted aryloxy groups, -NH(alkyl) groups, -NH(aryl) groups, $-N(aryl)_2$ groups, $-N(alkyl)_2$ groups, -N(alkyl)(aryl) groups, -S-alkyl groups, and S-aryl groups;

R^6 and R^7 may be part of the same alkyl group, alkenyl group, or aryl group such that R^4 and R^5 together with the two nitrogen atoms of the diazaphosphacycle form a ring; and

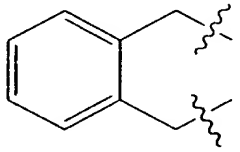
Y is a linking group selected from the group consisting of substituted and unsubstituted cycloalkyl groups, substituted and unsubstituted aryl groups, substituted and unsubstituted alkenyl groups, silyl groups, substituted alkyl groups,

and groups having the formula $-(CH_2)_n-$ wherein n is selected from the group consisting of 0, 1, 2, and 3.

3. The method of claim 2, wherein n is 0.

4. The method of claim 2, wherein Y is a cycloalkyl group, wherein one of the N atoms of the diimine is bonded to a first ring member C atom of the cycloalkyl group and the other N atom of the diimine is bonded to a second ring member C atom that is bonded to the first ring member C atom.

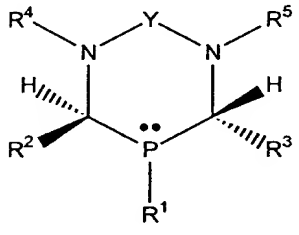
5. The method of claim 2, wherein Y has the formula



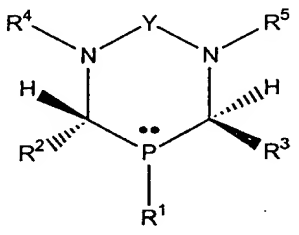
and the benzene ring of Y may be additionally substituted.

6. The method of claim 2, wherein R^2 and R^3 are identical but are not part of the same group.

7. The method of claim 2, wherein the diazaphosphacycle is selected from the group consisting of compounds of formula IIIA, compounds of formula IIIB, and mixtures thereof,



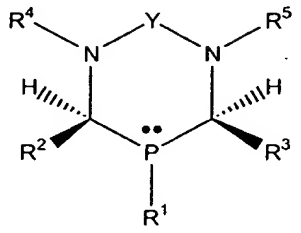
IIIA



IIIB

8. The method of claim 7, wherein n is 0.

9. The method of claim 2, wherein the diazaphosphacycle has the formula IIIC,



IIIC

10. The method of claim 9, wherein n is 0.

11. The method of claim 1, wherein the phosphine and the diimine are reacted in the presence of an acid.

12. The method of claim 2, wherein the phosphine and the diimine are reacted in the presence of the acid halide, the sulfonyl halide, the phosphoryl halide, or the acid anhydride, and at least one of R^4 and R^5 is not H.

13. The method of claim 2, wherein the phosphine and the diimine are reacted in the presence of the acid halide, and further wherein R^4 is a $-C(=O)-R^6$ group and R^5 is a $-C(=O)-R^7$ group.

14. The method of claim 1, wherein the phosphine and the diimine are reacted in the presence of phthaloyl dichloride or phthaloyl dibromide.

15. The method of claim 1, wherein R^1 comprises one or more $-PH_2$ group such that the phosphine is a polyphosphine.

16. The method of claim 15, wherein the polyphosphine is selected from the group consisting of 1,2-diphosphinoethane, 1,2-diphosphinoethylene, 1,3-diphosphinopropane, substituted and unsubstituted 1,2-diphosphinobenzene groups, substituted and unsubstituted

1,8-diphosphinoanthracene groups, substituted and unsubstituted 1,8-diphosphino-9,10-dihydroanthracene groups, substituted and unsubstituted 1,8-diphosphinoxanthene groups, and substituted and unsubstituted 1,1'-diphosphinoferrocene groups.

17. The method of claim 1, wherein the phosphine, the diimine, and optionally the acid halide are reacted in a substantially deoxygenated solvent comprising an ether, an alcohol, water, dichloroethane, or combinations thereof.

18. The method of claim 2, wherein a library of different diazaphosphacycles is produced using a combinatorial method.

19. The method of claim 1, further comprising reacting an acid halide, an acid anhydride, a phosphoryl halide, or a sulfonyl halide with the diazaphosphacycle to produce a second diazaphosphacycle wherein R^4 and R^5 are both –H in the diazaphosphacycle and at least one of R^4 and R^5 is not –H in the second diazaphosphacycle.

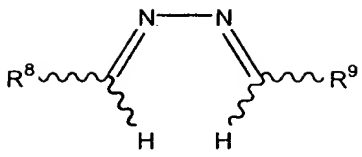
20. A method of synthesizing a diazaphosphacycle, comprising:

(a) reacting a diimine with an acid halide, a diacid dihalide, a sulfonyl halide, a disulfonyl dihalide, a phosphoryl halide, or a diphosphoryl dihalide to form a dihalo intermediate compound; and

(b) reacting the dihalo intermediate compound with a phosphine of formula R^1-PH_2 in the substantial absence of O_2 to form the diazaphosphacycle,

wherein R^1 is selected from the group consisting of substituted and unsubstituted aryl groups, substituted and unsubstituted alkyl groups, substituted and unsubstituted alkenyl groups, substituted and unsubstituted cycloalkyl groups, and substituted and unsubstituted ferrocenyl groups; and

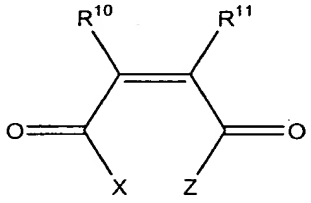
the diimine has the formula IV



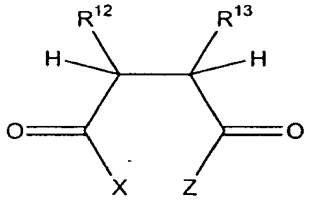
IV

wherein R^8 and R^9 are independently selected from the group consisting of substituted and unsubstituted aryl groups, substituted and unsubstituted alkyl groups, substituted and unsubstituted cycloalkyl groups, substituted and unsubstituted heterocyclyl groups, and substituted and unsubstituted ferrocenyl groups.

21. The method of claim 20, wherein the diimine is reacted with a diacyl dihalide, and the diacyl dihalide has the formula V or the formula VI

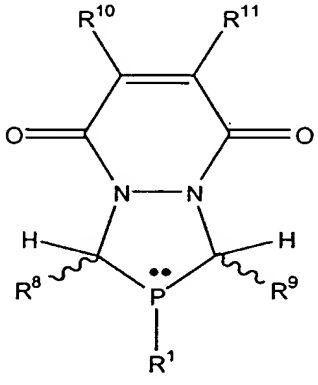


V

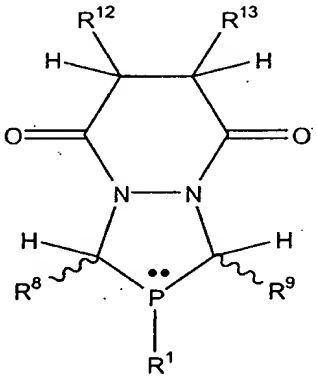


VI

and the diazaphosphacycle has the formula VII or the formula VIII



VII



VIII

wherein,

R^{10}, R^{11}, R^{12}, and R^{13} are independently selected from the group consisting of –H, substituted and unsubstituted alkyl groups, substituted and unsubstituted cycloalkyl groups, and substituted and unsubstituted aryl groups;

R^{10} and R^{11} may join together to form a substituted or unsubstituted aryl group or a substituted or unsubstituted cycloalkenyl group;

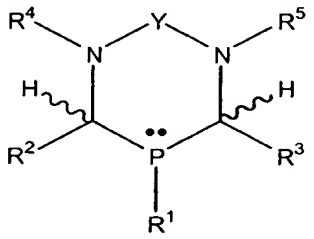
R^{12} and R^{13} may join together to form a substituted or unsubstituted cycloalkenyl group or a substituted or unsubstituted cycloalkyl group; and

X and Z are independently selected from –Cl or –Br.

22. The method of claim 21, wherein R^8 and R^9 are identical but are not part of the same group and R^8 and R^9 are substituted or unsubstituted aryl groups.

23. The method of claim 21, wherein the diacyl dihalide is phthaloyl dichloride.

24. A diazaphosphacycle, comprising a compound having the formula III and salts of the compound



III

wherein

R^1 is selected from the group consisting of substituted and unsubstituted aryl groups, substituted and unsubstituted alkyl groups, substituted and unsubstituted alkenyl groups, substituted and unsubstituted cycloalkyl groups, and substituted and unsubstituted ferrocenyl groups;

R^2 and R^3 are independently selected from the group consisting of substituted and unsubstituted aryl groups, substituted and unsubstituted alkyl groups, substituted

and unsubstituted cycloalkyl groups, substituted and unsubstituted heterocyclyl groups, and substituted and unsubstituted ferrocenyl groups;

R^4 is selected from the group consisting of -H, substituted and unsubstituted alkyl groups, substituted and unsubstituted cycloalkyl groups, substituted and unsubstituted aryl groups, trialkylsilyl groups, triarylsilyl groups, alkyldiarylsilyl groups, dialkylarylsilyl groups, $-C(=O)-R^6$ groups, $-S(=O)_2-R^6$ groups, $-P(=O)R^6R^7$ groups, and $-C(=NR^6)-R^7$ groups;

R^5 is selected from the group consisting of -H, substituted and unsubstituted alkyl groups, substituted and unsubstituted cycloalkyl groups, substituted and unsubstituted aryl groups, trialkylsilyl groups, triarylsilyl groups, alkyldiarylsilyl groups, dialkylarylsilyl groups, $-C(=O)-R^7$ groups, $-S(=O)_2-R^6$ groups, $-P(=O)R^6R^7$ groups, and $-C(=NR^6)-R^7$ groups;

R^6 is selected from the group consisting of substituted and unsubstituted alkyl groups, substituted and unsubstituted alkenyl groups, substituted and unsubstituted cycloalkyl groups, substituted and unsubstituted aryl groups, -OH groups, substituted and unsubstituted alkoxy groups, substituted and unsubstituted aryloxy groups, -NH(alkyl) groups, -NH(aryl) groups, $-N(aryl)_2$ groups, $-N(alkyl)_2$ groups, -N(alkyl)(aryl) groups, -S-alkyl groups, and S-aryl groups;

R^7 is selected from the group consisting of substituted and unsubstituted alkyl groups, substituted and unsubstituted alkenyl groups, substituted and unsubstituted cycloalkyl groups, substituted and unsubstituted aryl groups, -OH groups, substituted and unsubstituted alkoxy groups, substituted and unsubstituted aryloxy groups, -NH(alkyl) groups, -NH(aryl) groups, $-N(aryl)_2$ groups, $-N(alkyl)_2$ groups, -N(alkyl)(aryl) groups, -S-alkyl groups, and S-aryl groups;

R^6 and R^7 may be part of the same alkyl group, alkenyl group, or aryl group such that R^4 and R^5 together with the two nitrogen atoms of the diazaphosphacycle form a ring; and

Y is a linking group selected from the group consisting of substituted and unsubstituted cycloalkyl groups, substituted and unsubstituted aryl groups, substituted and unsubstituted alkenyl groups, silyl groups, substituted alkyl groups, and groups having the formula $-(CH_2)_n-$ wherein n is selected from the group consisting of 0, 1, 2, and 3.

25. A transition metal complex, comprising the diazaphosphacycle of claim 24 and a transition metal, wherein the phosphorus atom of the diazaphosphacycle is bonded to the transition metal.

26. The transition metal complex of claim 25, wherein the transition metal is selected from the group consisting of Rh, Ru, Pd, Pt, Ir, Ni, Co, and Fe.

27. The transition metal complex of claim 25, wherein the transition metal complex has catalytic activity.

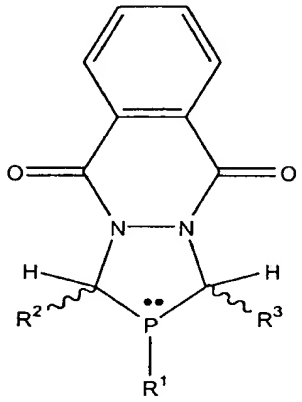
28. A method of catalyzing a chemical reaction, comprising using the transition metal complex of claim 27 as a catalyst.

29. The diazaphosphacycle of claim 24, wherein n is 0.

30. The diazaphosphacycle of claim 29, wherein R^4 and R^5 are both -H.

31. The diazaphosphacycle of claim 29, wherein R^4 is a $-C(=O)-R^6$ group and R^5 is a $-C(=O)-R^7$ group.

32. The diazaphosphacycle of claim 31, wherein, the diazaphosphacycle has the formula IX



IX

wherein the aromatic benzene ring in the compound of formula IX may be substituted or unsubstituted.

33. A transition metal complex, comprising the diazaphosphacycle of claim 31 and a transition metal, wherein the phosphorus atom of the diazaphosphacycle is bonded to the transition metal.

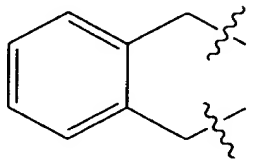
34. The transition metal complex of claim 33, wherein the transition metal is selected from the group consisting of Rh, Ru, Pd, Pt, Ir, Ni, Co, and Fe.

35. The transition metal complex of claim 33, wherein the transition metal complex has catalytic activity.

36. A method of catalyzing a chemical reaction, comprising using the transition metal complex of claim 35 as a catalyst.

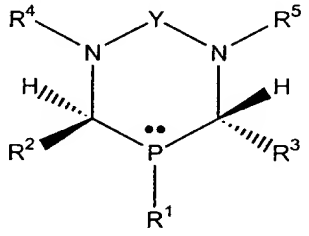
37. The diazaphosphacycle of claim 24, Y is a cycloalkyl group, wherein one of the N atoms is bonded to a first ring member C atom of the cycloalkyl group and the other N atom is bonded to a second ring member C atom that is bonded to the first ring member C atom.

38. The diazaphosphacycle of claim 24, wherein Y has the formula

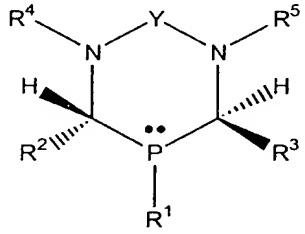


and the benzene ring of Y may be additionally substituted.

39. The diazaphosphacycle of claim 24, wherein the diazaphosphacycle has the formula IIIA, the formula IIIB, or is a mixture thereof



IIIA



IIIB

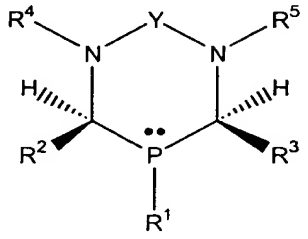
40. A transition metal complex, comprising the diazaphosphacycle of claim 39 and a transition metal, wherein the phosphorus atom of the diazaphosphacycle is bonded to the transition metal.

41. The transition metal complex of claim 40, wherein the transition metal is selected from the group consisting of Rh, Ru, Pd, Pt, Ir, Ni, Co, and Fe.

42. The transition metal complex of claim 40, wherein the transition metal complex has catalytic activity.

43. A method of catalyzing a chemical reaction, comprising using the transition metal complex of claim 42 as a catalyst.

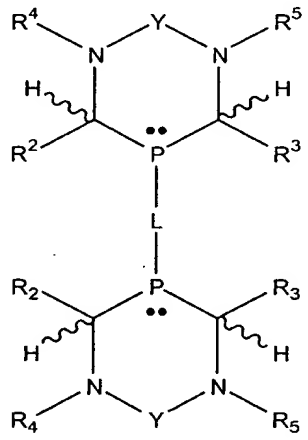
44. The diazaphosphacycle of claim 24, wherein the diazaphosphacycle has the formula IIIC



IIIC

45. The diazaphosphacycle of claim 24, wherein the diazaphosphacycle is present as a mixture of enantiomers.

46. The diazaphosphacycle of claim 24, wherein the diazaphosphacycle has the formula X



X

wherein L is a linking group selected from the group consisting of substituted and unsubstituted alkyl groups, substituted and unsubstituted alkenyl groups, substituted and unsubstituted aryl groups, and substituted and unsubstituted ferrocenyl groups.

47. The diazaphosphacycle of claim 46, wherein L is selected from the group consisting of ethane, ethylene, propane, benzene, anthracene, 9,10-dihydroanthracene, xanthene, and ferrocene.

48. A transition metal complex, comprising the diazaphosphacycle of claim 46 and a transition metal, wherein at least one of the phosphorus atoms of the diazaphosphacycle is bonded to the transition metal.

49. The transition metal complex of claim 48, wherein the transition metal is selected from the group consisting of Rh, Ru, Pd, Pt, Ir, Ni, Co, and Fe.

50. The transition metal complex of claim 48, wherein two of the phosphorus atoms of the diazaphosphacycle are bonded to the transition metal.

51. A combinatorial library of diazaphosphacycles, comprising a collection of different diazaphosphacycles according to claim 24.

52. A combinatorial library of transition metal complexes, comprising a collection of different transition metal complexes according to claim 25.

53. A method of synthesizing a diazaphosphacycle transition metal complex, comprising reacting the diazaphosphacycle of claim 24 with a starting transition metal complex to produce the diazaphosphacycle transition metal complex, wherein the starting transition metal complex includes at least one ligand that is replaced by the diazaphosphacycle.

54. The method of claim 53, wherein the ligand replaced by the diazaphosphacycle is selected from the group consisting of phosphines; amines; diamines; CO; Cl; Br; nitriles; 1,5-cyclooctadiene, norbornadiene, and other dienes; alkenes; arenes; ketones; alcohols; ethers; thiols; and sulfoxides.